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ORIGINAL ARTICLE

Cost-effectiveness of hip protectors in frail institutionalized elderly

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Abstract A randomized controlled trial was performed to examine the cost-effectiveness of external hip protectors in the prevention of hip fractures. Since the hip protectors were not effective in preventing hip fractures in our study, the main objective became to examine whether the use of hip protectors results in lower average costs per participant in the hip protector group as compared with the control group. In addition, the average costs of a hip fracture and subsequent rehabilitation in frail, institutionalized elderly were calculated. Residents from apartment houses for the elderly, homes for the elderly and nursing homes with a high risk for hip fractures were randomized to the hip protector group ($n = 276$) or control group ($n = 285$). Costs were calculated for the hip fracture and subsequent rehabilitation until 1 year after the fracture. Six months after each hip fracture, a nurse was interviewed and after 12 months, a questionnaire was sent to the general practitioner or nursing home physician to determine the utilization of health care resources. Differences in costs between the groups were analyzed using non-parametric bootstrapping. Eighteen hip fractures occurred in the intervention group and 20 hip fractures (in 19 persons) in the control group (log rank P-value = 0.86). The average costs per participant, including the costs of the intervention, were €913 in the intervention group and 502 in the control group (cost difference of €–411; 95% confidence interval: −723; 57). The average costs of a hip fracture and subsequent rehabilitation were €8100 (95% CI: 6716–10,010). The use of hip protectors was not associated with lower costs. In addition, the average costs of a hip fracture and subsequent rehabilitation in the first year after the fracture were estimated at €8100 in institutionalized elderly.

Keywords Cost analysis · Elderly · Hip fracture · Hip protector

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Introduction

Hip fractures constitute a growing health care problem due to the increasing number of frail elderly people. Worldwide, the number of hip fractures was estimated at 1.26 million in 1990, and this number is expected to increase to 4.5 million in 2050 [1]. Hip fractures are associated with increased mortality and morbidity, loss of independence and high costs for society [2,3,4,5].

A relatively new preventive option to reduce the incidence of hip fractures is the hip protector. To examine the effectiveness and cost-effectiveness of hip protectors in the prevention of hip fractures, the Amsterdam Hip Protector Study was started. This is a large randomized controlled trial ($n = 561$) in which individual randomization was used to assign persons to the intervention or control group. However, in this study, the hip protectors were not effective in reducing the incidence of hip fractures [6]. These results were confirmed by a recent update of the Cochrane review of Parker et al. [7].

In the latter, it was concluded that there is no evidence of the effectiveness of hip protectors from studies in which individual randomization was used. However, it was also concluded that data from studies using

cluster randomization indicate that for those living in institutional care with a high background incidence of hip fracture, a program of providing hip protectors appears to reduce the incidence of hip fractures.

Although a true effect may be present in the studies using cluster randomization, it is also possible that differences between the clusters, i.e. wards or nursing homes, or unknown co-interventions, play a role, which may hamper validity and generalizability. Therefore, we strongly believe that a design using individual randomization is preferable.

Currently, hip protectors are reimbursed in several countries. To give more insight into the costs, the main objective of this study was to examine whether the use of hip protectors results in lower average costs per participant in the hip protector group as compared to the control group.

The second objective of this study was to calculate the costs of a hip fracture and subsequent rehabilitation in frail, institutionalized elderly. In the literature, two studies were found in which the costs of a hip fracture and subsequent rehabilitation were calculated in The Netherlands [4,5]. In contrast to our study, these studies were performed in elderly people from the general population (71% and 58%, respectively, were living independently before the fracture). Since the costs may vary between independently living and institutionalized elderly, we determined the costs of a hip fracture and subsequent rehabilitation in institutionalized elderly.

Materials and methods

Design and subjects of the Amsterdam Hip Protector Study

The economic evaluation was performed within the framework of the Amsterdam Hip Protector Study, a randomized controlled trial in which individual randomization was used to assign persons to the intervention group ($n = 276$) or control group ($n = 285$). The subjects included were elderly persons, aged 70 years and over, who were living in apartment houses for the elderly, homes for the elderly, or nursing homes. All participants had to have a high risk for hip fractures, i.e. low bone density and/or a high fall risk. The contents of the screening method and the inclusion and exclusion criteria are described elsewhere [6]. The Ethical Review Board of the VU University Medical Center approved the study and all respondents (or their proxies in case of cognitive impairment) gave informed consent.

Intervention

Participants in the intervention group received four hip protectors, or five in case of urinary incontinence. Furthermore, all participants of the intervention and control group, or their nurses in case of cognitive impairment, received a leaflet with information on bone health and extrinsic risk factors for falls.

Economic analysis

The costs were calculated from a societal perspective. However, only direct health care costs were calculated, including the costs of hospitalization, surgery, consultations with the general practitioner and physiotherapist, and admission to a home for the elderly or nursing home. Direct non-health care costs, such as travel time to the hospital and waiting time, and indirect costs due to absenteeism from work, were considered of minor relevance in frail, institutionalized, elderly people.

To determine the costs of a hip fracture and subsequent rehabilitation, data regarding the use of health care resources were gathered for 1 year. Six months after each hip fracture, a nurse of the ward where the participant was living, was interviewed. After 12 months, a questionnaire was sent to the general practitioner or nursing home physician. Cost prices were estimated according to the Dutch guidelines for cost analysis in health care research [8]. An overview of all prices is presented in Table 1. When a person was admitted from a home for the elderly to a nursing home, the cost difference was used in the analyses (€145–67 per day).

Table 1 Prices used in the economic evaluation

	Euro
Intervention	
Hip protector (per Safehip)	70
Information (per leaflet)	0.45
Ambulance drive	156
Taxi drive	22
Academic hospital (per day)	
Normal care	356
Special care	573
General hospital (per day)	
Normal care	253
Special care	573
General practitioner (per consultation)	
By phone	9
Visit or in practice	18
Physiotherapy	
Academic hospital (per 30 min)	25
General hospital (per 30 min)	26
Visit at home (per consultation)	38
Other (per consultation)	19
Occupational therapy (per consultation)	19
Home for the elderly (per day)	67
Nursing home (per day)	145
Home care (per hour)	24
Family care (per hour)	9
Walking devices[a]	
Walking stick	9
Walking frame	66
Rollator	153
Wheelchair	453

[a]The costs of other devices, such as a toilet chair and anti-decubitus mattress, are not shown in the table

The costs of walking aids and other devices were estimated by asking three large suppliers in The Netherlands for their retail prices. For each device, the lowest price was used. In addition, the distributor of the Safehip hip protector was asked for his retail price.

Costs of surgery

Costs of surgery were calculated according to the bottom-up method, which is the method of first choice to estimate cost prices, because it uses individual patient data to estimate the costs of the operating-room, the personnel present during surgery, and materials used. Data on all hip fracture admissions (ICD codes 820.0 through 820.9) to the VU University Medical Center in 2000 and 2001 were extracted from the hospital information system (250 admissions, 244 persons). Discharge letters were used to gather additional information. The following inclusion criteria were used: (1) aged 70 years or older; and (2) hemiarthroplasty or osteosynthesis. Twenty-five admissions were excluded due to: incomplete data ($n=18$), primary hip fracture before 2000 ($n=3$), pathological fracture ($n=2$) and fracture due to traffic accident ($n=2$). In total, 225 admissions in 221 different patients were included. There were 91 admissions for a hemiarthroplasty and 134 for an osteosynthesis. The characteristics of the included patients are presented in Table 2. The costs of the operating room and the personnel present during surgery were estimated at €1195 per hour. The average duration of surgery was 2.45 h for the hemiarthroplasty and 2.23 h for the osteosynthesis. The total average costs per patient, including the costs of operation materials, were €3977 for the hemiarthroplasty and €3125 for the osteosynthesis. These results were used in the economic analyses.

Table 2 Characteristics of patients admitted to the VU University Medical Center for hip fracture surgery in 2000 and 2001

	Hemiarthroplasty (88 patients, 91 admissions)	Osteosynthesis (133 patients, 134 admissions)
Age in years[a]	83.1 ± 6.4	84.9 ± 6.2
Female[b]	70 (76.9%)	107 (79.9%)
Cause[b]		
Fall inside	73 (80.2%)	103 (76.9%)
Fall outside	11 (12.1%)	26 (19.4%)
Unknown	7 (7.7%)	5 (3.7%)
Duration of surgery (h)[a]	2.45 ± 1.27	2.23 ± 0.83
Other injuries[b]	8 (8.8%)	10 (7.5%)
Complications after surgery[b]	56 (61.5%)	79 (59%)
Discharge type[b]		
Home	24 (26.4%)	50 (37.3)
Nursing home	62 (68.1%)	76 (56.7%)
Deceased	5 (5.5%)	8 (6.0%)

[a]Presented are the mean ± SD
[b]Presented are the total number (and percentage) of admissions

Statistical analysis

First, the average costs of all hip fractures ($n=38$) that occurred within the Amsterdam Hip Protector Study were calculated. Second, the average costs of hip fractures in both the intervention group ($n=18$) and control group ($n=20$) were calculated. Third, the average costs for the total intervention group ($n=276$), including the costs of hip protectors and the provided information, and the total control group ($n=285$) were calculated.

Sensitivity analyses were performed for the most important cost components, i.e. hospital stay (including surgery) and admission to a home for the elderly or nursing home [4]. First, the influence of type of hospital, i.e. academic or general, was examined by replacing the costs of the academic hospital days by the costs of general hospital days. Second, the costs for the academic personnel present during surgery were replaced by the costs of general hospital personnel. Third, the costs were calculated after assuming that everyone was living in a nursing home before the fracture in order to correct for the different admission rates between the intervention and control group.

Because of skewed cost data, bias-corrected and accelerated bootstrapping with 2000 replications was used to calculate average costs, cost differences and accompanying 95% confidence intervals [9]. All analyses were performed by homemade Splus subroutines for bootstrapping (hj.ader@vumc.nl). All costs were estimated for the year 2001. If the costs were not available for that year, inflation figures of the Dutch Central Bureau of Statistics (CBS) were used to calculate the costs for 2001.

Results

In total, 561 elderly persons were included in the trial. The demographic characteristics of the intervention group and control group and the hip fracture patients are presented in Table 3. There was no statistically significant difference in the incidence of hip fractures (log rank P-value = 0.86). In the intervention group, 18 persons fractured a hip versus 19 persons in the control group [6]. In the control group, one person fractured two hips, making a total of 38 hip fractures in the study. Compliance changed from 61% after 1 month until 37% after 12 months [10]. Four persons in the intervention group were wearing the hip protector while fracturing the hip. During the follow-up of the study (average survival time 69.6 weeks), 83 persons of the intervention group and 79 persons of the control group died (log rank P-value = 0.31). Furthermore, within 1 year, 20 of 37 hip fracture patients (54.1%) died.

All interviews and questionnaires regarding health care utilization after a hip fracture were returned to the investigator. Table 4 shows that the mean number of academic hospital days and the mean number of consultations with the general practitioner and physiother-

Table 3 Baseline characteristics of the intervention and control group

	Intervention group	Control group
Total groups	$n = 276$	$n = 285$
Age in years[a]	85.5 (81.3–89.1)	86.3 (81.5–89.9)
Female[b]	242 (87.7%)	259 (90.9%)
Nursing home[b]	144 (52.2%)	133 (46.7%)
Home for the elderly[b]	112 (40.6%)	134 (47.0%)
Apartment house for the elderly[b]	20 (7.2%)	18 (6.3%)
Hip fracture patients	$n = 18$	$n = 19$[c]
Age in years[a]	85.2 (81.8–88.4)	85.1 (81.6–87.1)
Female[b]	16 (88.9%)	18 (94.7%)
Nursing home[b]	9 (50.0%)	10 (52.6%)
Home for the elderly[b]	8 (44.4%)	9 (47.4%)
Apartment house for the elderly[b]	1 (5.6%)	–

[a]Presented are the median (and interquartile range)
[b]Presented are the total number (and percentage)
[c]Twenty hip fractures occurred in 19 persons

apist were higher in the intervention group than in the control group. In both groups, two persons with a hip fracture were not operated. One of these persons was not admitted to a hospital and the other three were admitted for 3 days or less. When excluding these persons, the average duration in the general hospital increases to 12.3 (SD: 13.2) days in the intervention group and 10.8 (SD: 9.5) days in the control group.

The average costs of a hip fracture and subsequent rehabilitation were €8100 (95% CI: 6716–10,010) when including all 38 hip fractures (€1 = $0.89 at 31 December 2001).

The average costs of hospitalization were €7151 per hip fracture in the intervention group ($n = 18$) and €6073 per hip fracture in the control group ($n = 20$) (Table 5). The average costs of hospitalization and subsequent rehabilitation were €9166 per hip fracture in the intervention group and €7141 per hip fracture in the control group. These differences were not statistically significant.

Table 4 Utilization of most important health care resources

Type of utilization	Intervention group ($n = 18$)	Control group ($n = 20$)
Hospital		
Academic hospital (number of days)[a]	14.0 ± 9.4	11.0 ± 1.7
General hospital (number of days)[a]	10.8 ± 12.6	10.3 ± 9.5
Type of surgery[b]		
Hemiarthroplasty	7	9
Osteosynthesis	9	8
Type unknown	–	1
No surgery	2	2
General practitioner (number of consultations)[a]	7.3 ± 5.9	4.9 ± 5.0
Physiotherapy (number of consultations)[a]	25.5 ± 23.9	18.2 ± 26.1
Admitted from[b]		
Apartment house for the elderly to nursing home	1	–
Home for the elderly to nursing home	5	3
Home for the elderly to friend's home	–	1

[a]Presented are the mean ± SD
[b]Presented is the total number

Table 5 Average costs for a hip fracture and subsequent rehabilitation

Costs	Intervention group ($n = 18$)[a]	Control group ($n = 20$)[a]	Difference[b]
Hospital costs	7151 (5530–9042)	6073 (4884–7364)	−1078 (−3555; 1041)
Total costs	9166 (6778–12388)	7141 (5519–8818)	−2025 (−4978; 1253)

[a]Presented are the average costs (95% confidence interval obtained by bootstrapping)
[b]Presented are the differences in average costs between the intervention and control group (95% confidence interval obtained by bootstrapping)

Table 6 Average costs per participant in the intervention group and control group

Costs	Intervention group ($n = 276$)[a]	Control group ($n = 285$)[a]	Difference[b]
Hip fracture and rehabilitation	598 (325–984)	501 (291–786)	−97 (−498; 296)
Total costs including intervention	913 (643–1353)	502 (284–803)	−411 (−723; 57)

[a]Presented are the average costs (95% confidence interval obtained by bootstrapping)
[b]Presented are the differences in average costs between the intervention and control group (95% confidence interval obtained by bootstrapping)

The average costs per participant in the intervention group, excluding the costs of the intervention, were €598 in the intervention group ($n = 276$) and €501 in the control group ($n = 285$) (Table 6). When including the costs of the intervention, the average costs per participant in the intervention group were €913 and the average costs per participant in the control group were €502. These differences were not statistically significant.

The sensitivity analyses did not change the above results, although all cost differences between the intervention and control groups became somewhat smaller.

Discussion

In this study, an economic evaluation was carried out for the use of hip protectors in the prevention of hip fractures. The average costs per participant, including the costs of the intervention, were €913 in the intervention group and €502 in the control group (cost difference of €−411; 95% confidence interval: −723; 57). The average costs of a hip fracture and subsequent rehabilitation were estimated at €8100 (95% CI: 6716–10,010).

In the literature, three economic evaluations were found comparing the costs and effectiveness of hip protectors. In the first study, the authors combined hip fracture incidence data from their own study with data about the effectiveness of hip protectors as observed in five randomized controlled trials [11]. A disadvantage of combining data from different studies is that some issues, such as the influence of the hip protector on the severity of the fracture and the associated costs, cannot be taken into account. Also, in the second and third studies, data regarding the effectiveness of hip protectors were obtained from other studies [12,13]. In all three studies, the use of hip protectors was associated with lower costs. In our study, non-significant but substantially higher costs were found in the intervention group as compared with the control group. This difference in costs was mainly caused by the additional costs of hip protectors. However, also the mean number of academic hospital days and consultations with the general practitioner and physiotherapist were somewhat higher in the intervention group. There were no large baseline differences with respect to age, sex or living situation, which could explain these differences in health care utilization.

To our knowledge, only two other studies calculated the costs of a hip fracture in The Netherlands. In the first study, which was performed in 44 hip fracture patients, it was calculated that the average costs of hip fractures were $11,172 in 1993 (€13,899 in 2001 after correction for inflation), and the incremental costs $9540 (€11,870 in 2001) [4]. An advantage of this study is that they were able to calculate the incremental costs by selecting matched controls ($n = 44$). In our study, this was not possible, because it was designed to examine the effectiveness and cost-effectiveness of hip protectors. In the second study ($n = 102$), the average costs were estimated at €15,338 in 1998 (€17,253 in 2001) and the incremental costs, as compared to the 3 months prior to hip fracture, at €9306 (€10,468 in 2001) [5]. In these two studies, a top-down procedure [4] or tariffs [5] were used to estimate the costs of hip fracture surgery.

The costs of a hip fracture and subsequent rehabilitation in our study were estimated at €8100. Four explanations for the lower costs can be given. First, the mortality rate in our population is very high: 20 of 37 hip fracture patients died within 1 year. Of these, two persons died within a few days, and therefore costs were low. The second reason is the shorter hospital stay in our study: the intervention group stayed on average 14.0 days in the academic hospital and 10.8 days in the general hospital; the control group stayed on average 11.0 days in the academic hospital and 10.3 days in the general hospital. In the study of Van Balen et al. [5], the mean number of hospital days was 26. The difference in hospital days might be explained by the fact that the patients in our study, who were mainly living in homes for the elderly and nursing homes, could be discharged more quickly than independently living persons because of the care given in such homes. In addition, it sometimes happens that a hip fracture patient who is living independently cannot be discharged to his or her own home and has to wait in the hospital until a ''nursing home bed'' comes available. The third reason is that four of 37 patients (10.8%) were not operated. In the study of Van Balen et al. [5], this percentage was 7%. Potential reasons for giving conservative treatment are terminal illness or severe cognitive impairment. The last reason for the lower costs in our population is that almost all participants were already living in homes for the elderly or nursing homes. In the study of De Laet et al. [4], nursing home admission was one of the two most important cost components. In our study, people who were already living in a nursing home had no extra costs; and persons who came from a home for the elderly and were discharged to a nursing home had only the additional costs (€145–67 per day = cost difference between nursing home and home for the elderly). In addition, because half of the population was already living in a nursing home, they had no costs for consultations with the general practitioner and physiotherapist because these costs are already included in the cost price of a nursing home day in The Netherlands [8]. We postulate that the costs of a hip fracture and subsequent rehabilitation are lower for persons who are already institutionalized than in the general population, although this could not be tested with our data, because we only included institutionalized elderly. However, an earlier study which was performed in the United Kingdom was able to test this hypothesis and found that patients who were admitted from their own homes cost significantly more than patients who were admitted from long-term care [14].

Although the statistical power to detect a clinically significant difference in the incidence of hip fractures was good [6], this study may have lacked statistical power to detect clinically relevant differences in costs due to the low number of events. Another limitation of our study is that we did not include the costs of the screening for hip fracture risk and the costs of implementing the intervention. Therefore, the costs of the total intervention and control group were somewhat underestimated. In addition, we did not calculate the costs of hip fracture surgery for general hospitals. We did replace the academic personnel present during surgery by the costs of general hospital personnel in the sensitivity analyses, but in an earlier study it was suggested that also the type of materials used, i.e. gamma nails, might differ [5].

The strength of our study is that the effectiveness of the hip protector and the utilization of health care resources due to hip fracture were examined in the same study. In addition, this is one of the first large randomized controlled trials on the effect of hip protectors in which individual randomization was used. Furthermore, we calculated the costs of hip fracture surgery for academic hospitals according to the bottom-up method.

In conclusion, the economic evaluation indicates that the use of hip protectors was not associated with lower costs for hip fractures and subsequent rehabilitation in the intervention group. In addition, the average costs of a hip fracture and subsequent rehabilitation in the first year after the fracture were estimated at €8100 in institutionalized elderly.

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